Nutrient Monitoring Council Meeting #17

Meeting Minutes

Tuesday, August 2, 2022 9:00 a.m. – Noon

Meeting Summary

Welcome *Trevor Sample, Illinois Environmental Protection Agency*

Trevor, Chair of the NMC, welcomed members and speakers and reviewed the charge of the NMC in Illinois NLRS. Eliana Brown, Joan Cox, and Layne Knoche from University of Illinois Extension facilitated the call, recorded the minutes, and handled technical issues.

Statewide nutrient load update, *Tim Hodson, United States Geological Survey*

Tim Hodson provided an update on statewide nutrient loading for water years 2017-2021 using continuous water quality monitoring data provided by the USGS super gage network. Tim noted that past NLRS reports show a lot of interannual variability in nutrient loading, which continued this period. Statewide estimates indicate approximate increases of 10% nitrate and 30% phosphorus loads during the 2017-2021 period compared with baseline. These figures did not take into consideration the 30% increase in water yield 2017-2021 relative to baseline. The streamflow-adjusted data show statewide nitrate loads had declined 10% compared to baseline, whereas statewide phosphorus loads were similar to baseline. Tim also calculated loads for the Rock, Green, Illinois, Kaskaskia, Big Muddy, Little Wabash, Embarras and Vermilion Rivers. Sub-basin streamflow adjusted data for the period 2017-2021 showed a 10% increase in nitrate load from the Rock River, and a slight decrease in nitrate load from the Illinois River. Streamflow adjusted data showed a 30% increase in phosphorus load from the Illinois, Kaskaskia, and Little Wabash Rivers compared to baseline.

Illinois River Basin Phosphorus Loads 1979-2019, *Greg McIsaac, University of Illinois*

Greg McIsaac reviewed a study that investigated hot/cold spots, data trends, and factors that may explain P loading to the Illinois River. The work has been done in partnership with NREC, USGS, ISWS, and UIUC Agricultural and Biological Engineering. USGS flow data and discrete TP concentrations, mostly from IEPA's Ambient Water Quality Network were used, employing the method of WRTDS-K to calculate load estimates. Continuous concentration data from USGS was not used. Several point sources' discharge data were used. Data 2015-2019 showed increased P loads at Valley City compared to the 1989-1996 period. Seventy-eight percent of this increase appeared to come from the lower mainstem subwatershed of the Illinois River, and not the basin's tributaries. The remaining 22% of the increase in P load was from the Sangamon River in an amount equal to the increase in P discharged P by the Decatur Sanitary District. Possible causes of increases in TP loads could be due to P sinks associated with river gradient and sedimentation as well as zebra mussels. No large point sources could be found that explain the loading increase seen 2015-2019. At many monitoring locations, data show dissolved P increased while particulate P and TSS decreased during 2015-2019 compared to baseline, possibly due to conservation tillage, fertilizer stratification on the soil surface, and expanded tile drainage. The TP load decreases from Cook County during 2015-2019 were offset by the DuPage River P load increases, a watershed which also saw increased populations. The group suggests investigations that attempt to sort out the roles of factors such as chloride, sulfate, and zebra mussels, possible unidentified point sources, and into concentrated livestock facilities and manure application areas. They also suggest investigations into the reasons for large reductions in P loading in the Spoon River and Indian Creek watershed, and increases in Kickapoo Creek watershed, and the Sangamon River watershed between Fisher and Monticello.

Rock River Basin Nitrate Loads 1980-2019, *Greg McIsaac, University of Illinois*
Greg McIsaac reviewed that in comparison to baseline (1980-1996), the 2015-2019 period saw a large increase in nitrate yield, from 4.2 lb N/ac-yr at baseline to 21.5 lb N/ac-yr average recently. This increase was seen on the Rock River between Rockton and Joslin and excluding the Kishwaukee River load. To investigate the effects of possible factors leading to the 10,600 Mg N/yr increase in nitrate-N load in the lower Rock River, Greg estimated values of N (Mg N/yr) contributions for several possible factors: increased corn/soy acres (est. +1200), increased irrigated acres (est.+510), increased water yield (est.+1900), point source (est.~200), and flow measurement errors at Rockton (est.+2200). Reduced in-stream denitrification, decreased livestock numbers, and groundwater lag time contributions were not considered for this initial budget. Cumulatively, the estimates could explain 6,010 Mg N/yr increase in Rock River seen during 2015-2019 period compared to baseline. This amount would account for a little over half of the difference seen, leaving an approximate 5000 Mg N/yr difference unexplained. Calculations showed that for this budget shortfall to balance, it would require the lower Rock River flow to be comprised of 38% groundwater flow at 5 mg N/L. He said such a large contribution of groundwater could be plausible and would also support the lag time theory of nitrate concentrations appearing in the river following cropland leaching of nitrate 10-20 years earlier. Greg noted that shallow groundwater concentrations measured near the river are needed to investigate this hypothesis.

Preliminary results for groundwater nitrate modeling in the Rock River region, *Vlad Iordache, Illinois State Water Survey*
Vlad Iordache discussed data, methods, and results from testing the hypothesis that groundwater in the region could be a potential nitrate sink that contributes to the increased nitrate load seen in the Rock River 2015-2019 compared to baseline (1980-1996). He reviewed the subsurface (Tampico) and deep (Sankoty) sand and gravel aquifers in the region (Green River lowlands) and shared results of the IL Groundwater Flow Model developed by ISWS, ISGS, and IDNR. The model grids the glacial and bedrock layers into cells attributed by hydraulic conductivity, recharge, flow direction/speed (vectors), interaction with chemical species inputs, and head fluctuations associated with public/industrial and agricultural withdrawals. Water demand attribution was seasonal for agricultural irrigation and therefore, applied transiently. Data input included IEPA public water systems, ISWS public service lab (1980-89 and 2005-present), IDOA monitoring wells (2000-2014), and the ISWS IL Water Inventory Program data (1980 – present). County averages of withdrawals and county growth rates of withdrawals could be applied to the model. Monitoring wells supply good coverage of the region of interest. Initiating in the year 1980, Vlad explained simulation time-steps at the 9-months, 2004, 2015, and at 2030 demonstrating residence time of nitrates in the Tampico and Sankoty aquifers. Most of the upper Tampico aquifer was saturated by nitrate by 2030, and persistent “drainage” zones to the river were visible, indicating geologic heterogeneity in spots. Also, the simulation suggested domestic wells were at risk of nitrate contamination. The model attributed wetland zones for denitrification, assuming no denitrification by depth of sand and gravel layers. Under this assumption 40-50% of the nitrogen in groundwater may be denitrified before it gets to the river. Groundwater age assessment for the upper Tampico was approximately 15-20 years across the region, and for the lower Sankoty is more than 50 years, implying longer lag time in nitrate contamination reaching the lower aquifer, and longer residence time of contamination in that aquifer. Vlad explained that this simulation had applied nitrate all at once and future model improvements could include nitrate information applied across the model domain more heterogeneously to incorporate concentrations, timing and location of nitrate inputs. He solicited help from the NMC members in acquiring such data. He noted that transient modeling requires additional calibration to observed water quality data at all monitoring locations. The model may assist with computing Mg N/yr entering the Rock River surface water system through groundwater and may explain the budget shortfall in nitrate concentrations of the Rock River 2015-2019 compared to NLRS baseline.

Illinois River Basin Next Generation Monitoring, *Tim Straub, United States Geological Survey*
Tim Straub is Program Manager of the Illinois River Basin Next Generation Water Observing System. In late 2020 USGS selected the Basin as one of ten in the U.S to intensify monitoring due to its over-abundance of nutrients, associated HABs, range of river activities, land uses, and differences in gradient along its reach. Stakeholder meetings were held throughout Illinois this past year. Monitoring will include super gage data, two cruises of the Illinois River (May and August 2022), and seasonal monitoring at two or three locations in the basin during the ten-year project. The first seasonal station is at Indian Creek, Fairbury, IL. The project will model groundwater-surface water interactions and nutrients in the Quiver Creek and Kankakee River sub-basins and will use airborne electromagnetic (AEM) surveys of the Upper Fox River and the Lower Illinois River. Investigations are ongoing to understand why the HAB bloom occurred along the Seneca-Starved Rock-Henry stretch of the river in summer 2021 but not in 2022. An environmental DNA tracker will identify cyano-HABs species present and serve as an early warning instrument.

NMC Member Updates
The 2022 NLRS Conference will be held Nov. 1, 2022. It is being planned as a hybrid format, and details will be forthcoming.

Meeting Minutes

In attendance: Eliana Brown, University of Illinois Extension; Joan Cox, Illinois-Indiana Sea Grant; Paul Davidson, University of Illinois - Agricultural and Biological Engineering; Chris Davis, Illinois Environmental Protection Agency; Laura Gentry, University of Illinois/Illinois Corn Growers Association; Timothy Hodson, U.S. Geological Survey; Layne Knoche, University of Illinois Extension; James Lamer, Illinois Natural History Survey; Jong Lee, National Center for Supercomputing Applications UIUC; Mila Marshall, Sierra Club; Greg McIsaac, University of Illinois; Brian Metzke, Illinois Department of Natural Resources; Trevor Sample, Illinois Environmental Protection Agency; Cindy Skrukrud, Fox River Watershed; Tim Straub, United States Geological Survey; Nicole Vidales, Illinois Environmental Protection Agency; Michael Woods, Illinois Department of Agriculture; Vlad Iordach, Illinois State Water Survey ; Brian Rennecker, Illinois Department of Agriculture; Tom Minarik, Metropolitan Water Reclamation District of Greater Chicago; Amy Russell, United States Geological Survey; KJ Johnson, Illinois Fertilizer and Chemical Association; John Sloan, National Great Rivers Research and Education Center; Daniel Kim, UIUC Agricultural and Biological Engineering; Momcilo Markus, Illinois State Water Survey; Paul Keturi, Greater Peoria Sanitary District

Welcome, *Trevor Sample, IEPA*

Trevor reviewed the charge of the NMC in coordinating the development and implementation of monitoring activities. The monitoring provides estimates of five-year running average loads of nitrate-N and total phosphorus leaving Illinois compared to baseline conditions (1980-1996). It also provides estimates of nitrate-N and TP loads leaving selected NLRS priority watersheds compared to baseline conditions (1997-2011). It also assists with identifying nutrient load trends in Illinois and in the NLRS priority watersheds over time.

Statewide nutrient load update, *Tim Hodson, United States Geological Survey*

Tim Hodson provided an update on statewide nutrient loading for water years 2017-2021 using continuous water quality monitoring data provided by the USGS super gage network. He noted that since the Rock River data is not completed to date, it has not been subtracted out of statewide calculations.
While there is interannual variability, statewide estimates indicate approximate increases of 10% nitrate and 30% phosphorus loads during the 2017-2021 period compared with baseline. These figures did not take into consideration an increased water yield relative to baseline.

Tim also calculated loads for the Rock, Green, Illinois, Kaskaskia, Big Muddy, Little Wabash, Embarras and Vermilion Rivers. the Rock River experienced the largest increase in nitrate loading, approximately 60% over baseline. Tim noted that very large inter-annual variability was present in each sub-basin, but that the Rock and the Big Muddy Rivers showed increases during the 5-year period.

There is high confidence in the calculated change in nitrate load for most of the smaller watersheds. However, Tim notes, any long-term trend in nitrate load from the Illinois River was small relative to its interannual variability. And while the variability in nitrate load change seen on the Rock River is present, there is more confidence that there is an increase in loads coming from the Rock River.

In looking at phosphorus, the Illinois River is the most important contributor to the statewide load increase (30%) compared to baseline. This sub-basin is responsible for about half of the increased phosphorus loading seen statewide.

Streamflow adjustments: Since these systems change over time with changes in land management and streamflow, Tim incorporated changes in streamflow to add perspective on how changes in flow may have affected nutrient loading. He provided flow-adjusted estimates for nitrate loading. Streamflow 2017-2021 compared to baseline increased 30%, and it was evenly distributed across the state, with an exception of substantial increases in the Rock River. He explained that the change in nitrate loading in the Rock River did not appear to be associated with increased streamflow and remained at approximately 10% higher than baseline. For the Illinois River, however, when adjusted for streamflow, there appeared to be a decrease in nitrate loading on the Illinois River.

Flow adjustments cancelled out most of the change for phosphorus seen in the statewide calculation, suggesting the increase in P may have been associated with streamflow. The increase in P shown in southern Illinois watersheds did not seem to be as strongly associated with streamflow, which was surprising.

In summary, Tim noted that past NLRS reports show a lot of interannual variability in nutrient loading. Overall, the period 2017-2021 compared to baseline showed a 10% increase in nitrate load from the Rock River, and a 30% increase in phosphorus load from the Illinois, Kaskaskia, and Little Wabash Rivers. Since streamflow has increased 30% statewide compared with baseline, the streamflow-adjusted statewide data show nitrate loads statewide had declined 10% compared to baseline, whereas phosphorus loads statewide were similar to baseline.

Question (Greg McIsaac): Did you use flow adjustment using the standard normalization process of the WRDTS?

Answer (Tim H.): No, at present we don’t have a tool for normalization using continuous data. This is traditional flow adjustment, flow-weighted concentration, and the results should be similar.

Comment (Tim H.): Looking at smaller watersheds and different nutrient species dissolved, there are many interesting data stories that could be actionable by NLRS.

Question (Greg M.): Since IEPA had very little sampling in 2007 and 2008, did those figures contribute to your calculations?

Answer (Tim H.): No, 2007 and 2008 data don’t figure into the calculations for this five-year period or for baseline.

Illinois River Basin Phosphorus Loads 1980s-2019, *Greg McIsaac, University of Illinois*

Greg McIsaac explained that he, Tim Hodson (USGS), Momcilo Markus (ISWS), and Rabin Bhattarai and Daniel Kim (UIUC Agricultural and Biological Engineering) have been working for about eighteen months on this topic.

The group's manuscript on this study has recently been accepted for publication in the Journal of American Water Resources Association.

The motivation for this study, funded by NREC and USGS, was that the Illinois River is the largest contributor of phosphorus loads leaving the state, with a 30% increase over baseline (1980-1996) during the 2015-2019 period despite large decreases in P discharge from MWRDGC. The goals of this project were to identify hot/cold spots, data trends, and factors that may explain P loading to the Illinois River. USGS flow data and discrete TP concentrations, mostly from IEPA's Ambient Water Quality Network were used, employing the method of WRTDS-K to calculate load estimates. Continuous concentration data from USGS was not used. Other data included point source loadings from MWRD, the Sanitary District of Decatur (1990-2019) and the North Shore Water Reclamation District (north of Chicago), as well as some other point source discharge data from USEPA ECHO.

Greg showed three maps illustrating incremental TP yields from 41 monitored subwatersheds within the Illinois River Basin. TP yields during 1989-1996 where highest for subwatersheds in and downstream of the Chicago region (ranging up to 7 kg P/ha-yr). Negative TP yields in the lower mainstem subwatershed of the lower Illinois River ranging as much as 1.5 kg P/ha-yr. Greg mentioned one reason may be that the flatter gradient of the mainstem below Marseilles causes increased sedimentation. This area has a wide floodplain and many backwater lakes, so more sediment enters than leaves the Illinois River valley. Since P attaches to sediment, it is plausible that it accumulates in the sediments, which may account for negative incremental TP loading data seen during the 1989-1996 period.

Greg posed another possible P sink could be a growing population of zebra mussels during that period which could have sequestered P from the water column. While systematic population studies were not found, he noted a study by Blodgett et al. (1997) which reported a population explosion in 1993 followed by a crash in 1994-5.

During 2015-2019 incremental TP yield no longer showed accumulation of P in the lower mainstem. He noted that dissolved P had increased while particulate P and suspended solids had decreased since the comparison period (1989-1996), which may be due to changes in land management such as expansions of conservation tillage and tile drainage. He suggested that possibly more dissolved P is moving in runoff from conservation tillage because there is less incorporation of P into the soil. Furthermore, an expansion of tile drainage on the landscape may contribute to recent increase in dissolved P moving off the land.

A comparison of incremental TP yields during the 1989-1996 period to the 2015-2019 period shows the largest increase in incremental P load in the lower mainstem subwatershed of the Illinois River (below Marseilles not including the monitored tributaries). Of the over 6 million lb P/yr increase in load at the outlet at Valley City, 4.6 million lbs P/yr came from the lower mainstem subwatershed. Approximately 1.3 million was contributed by the Sangamon River, which is approximately equal to the amount of increase TP discharge by the Sanitary District of Decatur which receives wastewater from ADM with high P concentrations, which is probably from soybean processing. A TP yield increase from Kickapoo Creek at Waynesville may have been due to increased population in and around Bloomington. Also, Thorn Creek at Thornton has its own sanitary district and recently constructed a reservoir to store combined sewer overflows, management which seems to have greatly reduced P loading to that tributary. Greg noted that Indian Creek, a small tributary of the Spoon River is also decreasing in P loading and this should be investigated.

Greg explained that when subwatersheds were categorized by <9% developed (mostly agricultural) changes in TP yields were correlated with changes in water yield. However, some watersheds deviated from the correlation such as Indian Creek on the Spoon River, Lake Fork of the Salt Ck. on the Sangamon River and the lower mainstem subwatershed. For subwatersheds with >9% developed land cover, there was no discernable relationship between change in TP yield and change in water yield. TP yields in these subwatersheds tend to be more impacted by point sources.

Increases in P load of the lower mainstem are not correlated with increased flow (water yield). There was some evidence for decreasing P load with higher flows, possibly since at high flows there is more out-of-bank flow transporting P to floodplains.

One of the simplest explanations for the increased TP yield from the lower mainstem may be that more incoming P loading has been occurring as dissolved P in recent years compared to baseline. As the dissolved P (DP): total P (TP) ratio increased, more P was transported downstream to Valley City, perhaps explaining the higher load at Valley City.

There is an interesting correlation of DP:TP to chloride concentrations. A few studies of incubated river sediments having high chloride concentrations support the effect of chloride on mobilization of P from sediments. This could be happening in the lower mainstem.

Future studies should investigate the relationships of sediment chemistry to P mobilization, looking at the effect of nitrate and sulfate concentrations, which play a role in redox potential of sediments.

In summary, 2015-2019 saw increased P loads at Valley City compared to the 1989-1996 period. Seventy-eight percent of this increase appeared to come from the lower mainstem subwatershed of the Illinois River, and not the basin's tributaries. The remaining 22% of the increase in P load was from the Sangamon River in an amount equal to the increase in P discharged P by the Decatur Sanitary District. Possible causes of increases in TP loads could be due to several factors that were briefly explained here and warrant further investigation. No large point sources could be found that explain the loading increase. At many monitoring locations, dissolved P increased while particulate P and TSS decreased, possibly due to conservation tillage, fertilizer stratification on the soil surface, and expanded tile drainage. The TP load decreases from Cook County during 2015-2019 were offset by the DuPage River P load increases, a watershed which also saw increased populations. The group suggests investigations that attempt to sort out the roles of factors such as chloride, sulfate, and zebra mussels, possible unidentified point sources, and into concentrated livestock facilities and manure application areas. They also suggest investigations into the reasons for large reductions in P loading in the Spoon River and Indian Creek watershed, and increases in Kickapoo Creek watershed, and the Sangamon River watershed between Fisher and Monticello.

Question (Tim H.): What was the sediment trend for the lower Illinois River mainstem?

Answer (Greg): A very slight increase in TSS, but not a strong trend. There was still net deposition of TSS in the lower mainstem.

Comment (Tim H.): In my presentation I had suggested the increase in P coming out of IL seemed to be associated with an increase in streamflow, but that interpretation isn't consistent with your findings, which suggested no relationship between flow and P yield in the lower Illinois River mainstem.

Comment (Jim Lamer): The Peoria Reach of the Illinois River has high densities of silver carp, while the densities above Starved Rock [Marseilles] are lower. Also, high density expansion of silver carp followed a very strong year class in 2008. Some high densities of Asian carp have been attributed to benthic enrichment for macroinvertebrates, and mark and re-capture estimates have shown 300,000 carp per river mile in the LaGrange reach (below Peoria pool). Some studies have looked at their feces accumulation in benthos. In addition to investigating zebra mussels, Asian carp may be a potential P sink in the lower Illinois River mainstem.

Response (Greg): Could you send me references to those studies?

Comment (Jim Lamer): Yes.

Question/Comment (Michael Woods): Noting the increase in TP in agricultural lands around Chicago, could an increase in sewage sludge applications on agriculture land also increase TP on these lands, and thus contribute to increase flow of TP into the rivers? Recently the Tribune published a story on sewage sludge contaminated with toxic 'forever chemicals' spread on thousands of acres of Chicago-area farmland.

Answer (Greg): MWRD has studied loss of P from sludge at its research site in Fulton County. They did not see much loss of P from sludge applied to ag land. However, land quality and sludge quantities vary as well, and could be a potential source.

Rock River Basin Nitrate Loads 1980-2019, *Greg McIsaac, University of Illinois*

Greg McIsaac reviewed findings from a study done with funding from Illinois Corn Growers Association in consultation with Megan Dwyer and Daniel Perkins. He reviewed that since more of the Rock River basin is in WI than in IL, the NLRS calculates loads at the Rockton, IL gage near the Wisconsin border. These loads are subtracted from the loads calculated downstream at Joslin to estimate the Illinois portion of Rock River loads, although this does not include part of Illinois drained by the Pecatonica River. Joslin is the furthest downstream gage on the Rock River. The Green River is monitored at Geneseo, which is upstream of its confluence with the Rock, allowing separate consideration of the Green River Watershed.

Greg also reviewed that in comparison to baseline (1980-1996), the 2015-2019 period saw a large increase in nitrate yield, from 4.2 lb N/ac-yr at baseline to 21.5 lb N/ac-yr average recently. This increase was seen on the Rock River between Rockton and Joslin and excluding the Kishwaukee River load. Potential explanations include changes in instream denitrification, loss to groundwater, or other factors.

Several factors were reviewed. Greg compared nitrate-N yields with percent landcover of corn/soy, average water yield, and with county manure N produced using data from three periods (1946 to 1971, 1980-1996, and 2015-2019). The analyses of several watersheds supported a possible lag time of about 10-20 years between land management change and river nitrate yield change.

In years following droughts, nitrogen concentrations and yields were often above normal in many streams, however, this was not seen on the lower Rock River, further supporting the lag time theory. Greg listed several possible sources of increased nitrate load, including increase in corn/soy acres, irrigated acres, water yield, livestock numbers, increased point source discharge due to population increases, reduced in-stream denitrification from increased streamflow, and possible flow measurement errors at Rockton.

To investigate the effects of possible factors leading to the 10,600 Mg N/yr increase in nitrate-N load in the lower Rock River, Greg estimated values of N (Mg N/yr) contributions for several possible factors: increased corn/soy acres (est. +1200), increased irrigated acres (est.+510), increased water yield (est.+1900), point source (est.~200), and flow measurement errors at Rockton (est.+2200). Reduced in-stream denitrification, decreased livestock numbers, and groundwater lag time contributions were not considered for this initial budget. Cumulatively, the estimates could explain 6,010 Mg N/yr increase in Rock River seen during 2015-2019 period compared to baseline. This amount would account for a little over half of the difference seen, leaving an approximate 5000 Mg N/yr difference unexplained.

Greg questioned the role of groundwater in accounting for this difference. Calculations showed that for this budget shortfall to balance, it would require the lower Rock River flow to be comprised of 38% groundwater flow at 5 mg N/L. He said such a large contribution of groundwater could be plausible and would also support the lag time theory of nitrate concentrations appearing in the river following cropland leaching of nitrate 10-20 years earlier. Greg noted that shallow groundwater concentrations measured near the river are needed to investigate this hypothesis.

Question (Tim H.): It appears that the corn/soy acres increased over time, saturating the landscape circa 1980 and flattening off with a slight increase ever since. Why such an abrupt flattening?

Answer (Greg): Acreage dropped in 1983 attributable to a USDA payment-in-kind program encouraging farmers not to plant. This period of the 1980s also saw low corn prices and therefore presented less economic incentive to plant corn.

Comment (Tim H.): It would also be interesting to investigate the increase corn/soy acres over time alongside corn/soy yield data over time, since yields have continued to increase per acre.

Comment (Greg): Yes, this could be a partial explanation for why we saw a decrease in nitrate loading in some watersheds. There has also been an increase in tile drainage. Several watersheds show a decrease in nitrate loads, which may be explained by improvements in N fertilizer use-efficiency on corn because fertilizer input has not increased as fast as corn yields have increased.

Preliminary results for groundwater nitrate modeling in the Rock River region, *Vlad Iordache, Illinois State Water Survey*

Vlad Iordache discussed data, methods, and results from testing the hypothesis that groundwater contributes/mediates the increased nitrate load seen in the Rock River 2015-2019 compared to baseline (1980-1996). He reviewed the subsurface (Tampico) and deep (Sankoty) sand and gravel aquifers in the region. Vlad noted that while runoff from the Rockford region principally flows directly into the river, the region colloquially known as the Green River lowlands could be a potential nitrate sink. He referenced large population centers and irrigation pivots as potential sources for nitrate to groundwater.

The IL Groundwater Flow Model was developed with ISGS and IDNR. Regional stratigraphy updates from ISGS feed directly into the model, which contains 16 bedrock layers and 9 glacial deposit layers. He explained the gridded dimensions of the model which are attributed with several factors including hydraulic conductivity, recharge, flow direction/speed (vectors), interaction with chemical species inputs, and head fluctuations associated with public/industrial and agricultural withdrawals. He explained how the water demand attribution can be seasonal for agriculture, hence the use of monthly time scales in the transient modeling versus the static modeling. Data input to the model included IEPA public water systems and the ISWS public service lab (1980-89 and 2005-present), which captures voluntary residential sampling. Vlad noted that the inputs were biased toward the withdrawals from the deeper Sankoty aquifer, and thus biased toward cleaner water. Another data source used was the IDOA monitoring wells (2000-2014) which monitored nitrate regularly and from which a subset of surficial unconfined aquifer wells allowed good spatial coverage of the area of interest. Vlad noted that this subset did not show an increase trend of nitrate concentration over time, but rather a steady 15-20 mg/L steady state concentration. The main source utilized in the model was the ISWS IL Water Inventory Program data, which captures annual reports of large water users. These reports were voluntary 1980 – 2014 and required since 2015. Using these data, county averages of withdrawals could be extrapolated. Also, county growth rates of withdrawals could be applied to the model by extrapolating irrigation increases, using data from three-year increments. The model can run steady state during the part of the year without irrigation, and shift to transient during the irrigation swings. Vlad discussed model calibration methods.

Potentiometric surface maps illustrate the slower flow of groundwater in the Green River lowlands, and stratigraphic maps show sands in the region of interest. A map layer of monitoring wells showed good coverage of the region of interest.

Vlad reported time-steps from the model demonstrating distinct phases of nitrate movement through the system. The model initiated at the year 1980. The first time-step ran nine non-irrigating months into the simulation, a point which represented public withdrawals only. At this time-step most of the nitrate had flushed to the main river. Regions far from the river showed infiltration. At the 2004 time-step during the middle of an irrigation cycle, the simulation showed that not enough time had passed to show nitrate transport to the aquifers. Only the flow regime had been affected. By the midpoint of the model, 2015, nitrate began to saturate the system toward the southern portions (central lowlands) and showed some resistance to penetration of the deep aquifer. Vlad explained this was due to the confining layer between the Tampico and Sankoty which covers a portion of that region and pushes groundwater flow (nitrate) toward the river. However, in the portion of the central lowlands where the confining layer is gone, more nitrate infiltration to groundwater was seen in the simulation. There is a region near Joslin, toward the confluence of the Green and Rock Rivers, laden with silts and loesses. This area has low hydraulic conductivity, and nitrate flowed on the surface and out to the river. At the end of the simulation, in 2030, most of the upper Tampico aquifer was saturated by nitrate, and persistent "drainage" zones to the river were visible, indicating geologic heterogeneity in spots. This last time-step of the simulation suggested domestic wells were at risk of nitrate contamination.

Two monitoring well clusters, one crossing a region predicted by the model to have high nitrate concentrations (WTS-91 C/D) and another with low predicted nitrate concentrations (WTS-91 E/F), could be sampled in the future to verify whether simulated contaminant transport reflects reality.

The model assumed no denitrification by depth, and only attributed wetland zones for denitrification. Under this assumption 40-50% of the nitrogen in groundwater may be denitrified before it gets to the river.

Groundwater age assessment for the upper Tampico was approximately 15-20 years across the region, decreasing as it neared the rivers. Vlad noted that as groundwater flow takes residence below first order streams, residence time increases, and he wondered whether groundwater under the streams was allowing nitrate to persist. There is older water near Joslin which slows and holds in the system, but any nitrate in the simulation flushed to the river after 15-20 years. Vlad noted that this simulation also supports what Greg mentioned earlier about nitrate lag time in the region.

Vlad noted that the water age assessment for the lower Sankoty is greater than 50 years, with some portions possibly flowing to the Illinois River. This implies a longer lag time in nitrate contamination reaching the lower aquifer and also the residence time of contamination in that aquifer. He noted that irrigation typically withdraws from the lower aquifer.

In the future, nitrate can be applied across the model domain more heterogeneously, if there is support/consensus that is happening. Nitrate should also be applied transiently. Vlad explained that this simulation had applied nitrate all at once. He noted the transient model required additional calibration to observed water quality data at all monitoring locations. He noted that at Rock Falls, too much nitrate was input and at Byron, to little nitrate was input, but that model calibration would improve with time.

The modeling information can tie in to the NLRS surface water nitrate loading data. The model could assist with computing Mg N/yr entering the system through groundwater and may explain the budget shortfall in nitrate concentrations of the Rock River 2015-2019 compared to NLRS baseline. Vlad solicited help from NMC members in finding data sources that could attribute the model cells with nitrate concentration, timing, and location.

Question (Tim H.): Tim summarized his understanding of Vlad's presentation noting that in a large surficial aquifer most of the water reaching the stream has been relatively clean in the past, not impacted by agricultural fertilizer inputs. This could explain why nitrate loads in the stream were low at baseline. Over time the aquifer saturates with nitrates from increased ag inputs the groundwater flow model supports a legacy effect. Tim asked for clarification of the difference between the Rock River and the Green River?

Answer (Vlad): Flows are much higher in the Rock than in the Green River. Also, there are higher population centers on the Rock.

Question (Tim H.): Where are the monitoring wells?

Answer (Vlad): A map of monitoring well locations in this region, as well as access to the data can be found at the following link: https://aqueduct.isws.illinois.edu/grl-monitoring.html. Broadly speaking, monitoring wells are located in both the Rock and Green River watersheds, and generally south and east of the Rock River.

Comment (Greg): The aquifer is thicker near the Rock, with a longer lag time too [since it is unconfined near the Rock]. There is also much more irrigation near the Rock.

Comment/screenshare (Tim H.): Tim shared a U.S. Department of Agricultural Tile Drainage Probability map of Illinois. He noted that more runoff diverted to tiles, and not to the aquifer, that perhaps we are not seeing a buffer effect since in the Green River area, runoff is going to tiles not the aquifer.

Comment (Vlad): Data on tile use change over space/time is needed for the model. He noted the removal of wetlands in the regions and modifications to flood mitigation infrastructure could be additional valuable model inputs.

Illinois River Basin Next Generation Monitoring, *Tim Straub, United States Geological Survey*

Tim Straub explained that Jim Dunker held around 20 stakeholder meeting throughout Illinois this past year and that collaboration and coordination is very important to the success of this ten-year program.
He reviewed that the IL River Basin is representative of the region due to the range of river activities, land uses, and differences in gradient along its reach. He noted that previous work on the Illinois and Embarras Rivers demonstrated their dynamics for nutrient loss and transport, a factor also weighted in the Basin's selection.

Tim showed a map of the eight super gage locations, with the ninth added by MWRD on the Des Plaines River last year. The map showed the location of other agencies' monitoring sites, as well. He noted that observation assessments at these locations will will be applicable to both nutrient and HABs priorities. Tim solicited input from the NMC members as to potential Next Generation WOS monitoring sites on the Green River as well.

Upcoming activities that will complement the super gage data include a cruise of the entire of Illinois River using a super gage onboard a boat. One cruise was completed in May and the other will be completed next week. He noted the data would be used for models on carbon and other nutrient sinks and for tracking sources of nutrients and sediments. It would also be used at several scales.

Seasonal snapshots throughout the Illinois River Basin also support stakeholder input. The seasonal monitoring will happen at two or three locations in the basin during the ten-year project. One location has been chosen and nitrate and turbidity probes have already been reinstalled at a monitoring site at Indian Creek, Fairbury, IL.

The Next Generation project plans to model groundwater-surface water interactions and nutrients in the Quiver Creek and Kankakee River sub-basins. Tim showed a mockup of a dashboard that would demonstrate dynamics between in-stream and groundwater well areas. Information will be sourced from nutrient sensors and velocity meters in wells. Additionally, to build on the groundwater work, the project will use airborne electromagnetic (AEM) surveys of the Upper Fox River and the Lower Illinois River. It was recently tested locally in Champaign County on a transect of the Mahomet Aquifer due to proximity to the office.

HABs are a concern in the Upper Illinois River. Tim noted the 2021 bloom at Starved Rock and showed satellite data. Other data complimented chlorophyll *a* concentrations from the 2021 bloom with near field camera images, a technique used to document hotspots in the river. He noted continuous monitoring displayed phycocyanin, a good indicator of HABs, peaking and moving down river from Seneca, to Starved Rock, and then to Henry, IL. Investigations are ongoing to understand why the HAB bloom occurred in 2021 and not in 2022. An environmental DNA tracker to support the HABs work is on its way and will be used in the Illinois Basin. It will identify cyano-HABs species and serve as an instrument for early warning of HABs.

Question (Greg): Can groundwater-surface water interaction studies be done in the Rock River Basin?

Answer (Tim S.): This instrumentation could apply, but unfortunately the funding for this work must be applied to the Illinois River Basin.

Comment (Vlad): There are two monitoring wells near the Rock River that would be ideal for groundwater-surface water interaction study.

NMC Member Updates

Eliana Brown announced the 2022 NLRS Conference will be held on November 1, 2022. It is currently being planned as a hybrid format, and details will be forthcoming.